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PHILOSOPHICAL TRANSACTIONS. PART II.

XLI. *Account of the Transit of Venus over the Sun's Disk, as observed at Norriton, in the County of Philadelphia, and Province of Pennsylvania, June 3, 1769. By William Smith, D. D. Provost of the College of Philadelphia; John Lukens, Esquire, Surveyor-General of Pennsylvania; David Rittenhouse, A. M. of Norriton; and John Sellers, Esquire, one of the Representatives in Assembly for Chester County; the Committee appointed for that Observation, by the American Philosophical Society, held at Philadelphia, for promoting useful Knowledge. Communicated to the said Society, in Behalf, and by Direction, of the Committee, by Doctor Smith; and to the Royal Society of London, by Nevil Maskeline, B. D. Astronomer Royal.*

GENTLEMEN,

Read Nov. 23, 1769. **A**MONG the various public-spirited designs, that have engaged the attention of this Society since its first institution, none
VOL. LIX. P p does

does them more honour than their early resolution to appoint Committees, from their own members, to make as many observations, in different places, of that rare phenomenon, the transit of Venus over the Sun's disk, as they had any probability of being able to defray the expence of, either from their own funds, or the public assistance they expected.

As the members of the Committee above mentioned live at some distance from each other, I am therefore now, by their direction, and in their behalf, to collect, and lay before you, the whole of the Norriton observations; distinguishing however, so far as may be necessary, the part of each observer; and going back to the first preparations. For I am persuaded that the dependance which the learned world will place on any particular transit account, will be altogether in proportion to the previous and subsequent care, which they find hath been taken, in a series of accurate and well-conducted observations, for regulating the time-pieces, and ascertaining the latitude and longitude of the place of observation, &c. And I am the more desirous to be particular in these points, in order to do justice to Mr. Rittenhouse, one of our Committee; to whose extraordinary skill and diligence is owing whatever advantage may be derived in these respects to our observation of the transit itself. It is further conceived, that the learned and curious will be desirous to have not only the work relative to each particular transit account, but the materials also, that they may have an opportunity to examine and conclude for themselves. And it is a pleasure to us that we are able to communicate so complete a set of observations in every material article.

The

The great discouragement which the different Committees laboured under, at their first appointment by this Society, was the want of proper apparatus, especially good telescopes. The generosity of our Provincial Assembly soon removed a very considerable part of this discouragement, not only by their vote to purchase one of the best reflecting telescopes, with Dollond's micrometer, but likewise by their subsequent benefaction of one hundred pounds, for erecting observatories, and defraying other incidental expences. It was foreseen that, on the arrival of this telescope*, added to other private ones that could be procured in this city, and the fitting up the instruments belonging to the honourable Proprietaries, viz. the large astronomical sector, and the equal altitude and transit instrument, nothing would be wanting for the city observatory, erected in the State-house Square, but a good time-piece, which was easily to be procured.

We remained, however, still at a loss how to furnish the Norriton observatory. But this difficulty gradually vanished. Early in September, 1768, soon after the nomination of the Committees, I received a letter from that worthy and honourable gentleman, Thomas Penn, Esquire, one of the Proprietors of this province, expressing his desire that we would exert ourselves in observing the transit, for which our situation was so favourable; and inclosing some copies of Mr. Maskelyne's directions for that purpose.

* This telescope came to hand in April, 1769. It was made by Nairne, $4\frac{1}{2}$ feet, and its greatest magnifying power 400 times; with an excellent micrometer.

This gave an opportunity, which I embraced immediately, to inform Mr. Penn, that this Society, before the receipt of his letter, had appointed two* Committees for the business he proposed; that the Assembly had generously ordered one hundred pounds, sterling, to purchase one telescope, as above set forth; but that we should be at a great loss for a telescope and micrometer, of the like construction, for the Norriton observatory; requesting him to order a reflector of $2\frac{1}{2}$ feet, with Dollond's micrometer, to be got ready in London; which I was in hopes I should prevail on our College to pay for, and take for their own use, as soon as the corporation should have an opportunity of meeting. It was not long before I had the pleasure to hear that Mr. Penn had ordered such a telescope. which came to hand in due time, with a most obliging letter, expressing his satisfaction in the spirit shewn at Philadelphia for observing this curious phenomenon, and concluding as follows:

“ I have sent by Captain Sparks a reflecting telescope, with Dollond's micrometer, exact to your request, which I hope will come safe to hand. After making your observation with it, I desire you will present it, in my name, to the College. Messieurs Mason and Dixon tell me, they never used a better than that which I formerly sent to the Library Company of Philadelphia, with which a good observation† may be made, although it has no micrometer.” —

* A third Committee was afterwards appointed, to observe at or near Cape Henlopen.

† Mr. Owen Biddle, who was appointed by the Society to conduct the observation near Cape Henlopen, had this telescope;

We were now enabled to furnish the Norriton observatory, as follows :

1. A $2\frac{1}{2}$ feet Gregorian reflector, with a Dollond's micrometer, made by Nairne, its magnifying powers 55, 95, 135, and 200 times. The gift of the honourable Thomas Penn, Esquire, to the College of Philadelphia. Used by Doctor Smith.
2. A refractor of 42 feet, its magnifying power about 140. The glasses sent to the Assembly, with the large reflector, from England. Used by Mr. Lukens.
3. Mr. Rittenhouse's refractor, with an object glass of 36 feet focus, and a convex eye glass of 3 inches, magnifying about 144 times. Used by himself.
4. An excellent clock ; a transit telescope, nicely moving in the plane of the meridian ; and a very accurate equal altitude instrument, supported, in the observatory, on a stone pedestal. These three articles were also Mr. Rittenhouse's private property, and made by himself, whereof some mention is made below.
5. An astronomical quadrant, $2\frac{1}{2}$ feet radius, made by Sisson ; the property of the proprietors of East New Jersey ; under the care of the right honourable William Earl of Stirling, surveyor-general of that province, who kindly permitted us the use of it.

nothing being desired here but the contacts, and their exact time, which he obtained to great satisfaction, as by his report may appear.

As

As Mr. Rittenhouse's dwelling at Norriton is 20 miles N. W. of Philadelphia, our other engagements did not permit Mr. Lukens, or myself, to pay much attention to the necessary preparations; but we knew that we had entrusted them to a gentleman on the spot, who had, joined to a complete skill in mechanics, so extensive an astronomical and mathematical knowledge, that the construction, use, and management of all the necessary apparatus are perfectly familiar to him. The dull and rainy weather prevented our setting out for his house till Thursday, June 1; and we found, on our arrival there, every preparation so forward, that we had little to do but to examine and adjust our respective telescopes to distinct vision. Mr. Rittenhouse had compleated his observatory, fitted up the different instruments, and made a great number of observations, for fixing the latitude and longitude of the observatory, and ascertaining the going of his time-piece. The laudable pains he has taken in these material articles will best appear from the work itself, which I received from him a few days ago, with the following very obliging letter; giving me a liberty which his own accuracy, care, and abilities leave me no room to exercise; and therefore what follows is entirely as he drew it up, viz.

“ To the Reverend Doctor SMITH.

“ Dear Sir,

“ The enclosed is the best account I can give of
 “ the contacts, as I observed them, and of what I
 “ saw during the interval between them. I should
 “ be glad you would contract them (and the other
 “ papers)

“ papers) into a smaller compass, as I would have
 “ done myself, if I had known how. I beg you
 “ would not copy any thing merely because I have
 “ written it, but leave out what you think super-
 “ fluous.

“ I am, with great esteem and affection, Yours,

Norriton, July 18, 1769. “ DAVID RITTENHOUSE.”

Mr. Rittenhouse's account of the observations made by him, at Norriton, before and after the transit of Venus, June 3, 1769; for determining the longitude and latitude of his observatory, regulating his clock, &c.

“ Early in November, 1768, I began to erect an
 “ observatory, agreeable to the resolutions of the
 “ American Philosophical Society; but, through
 “ various disappointments from workmen and wea-
 “ ther, could not complete it till the middle of
 “ April, 1769. I had for some time expected the
 “ use of an equal altitude instrument from Philadel-
 “ phia; but finding I could not depend on having
 “ it, I fell to work and made one, of as simple a
 “ construction as I could contrive. It has a good
 “ telescope of $3\frac{1}{2}$ feet focal length, with two hori-
 “ zontal and one vertical wire, in the focus, and is
 “ very easily adjusted to a plummet wire, 4 feet in
 “ length, by two screws; one of which moves it in
 “ a north and south, the other in an east and west
 “ direction. The 20th of March this instrument
 “ was

" was finished, and put up out of doors, the observatory being not yet ready.

" I had, however, for some weeks before this, with my 36 feet refractor, observed eclipses of Jupiter's first satellite, in such a manner, that though my equal altitude instrument was not finished, and consequently I could not set my time-piece to apparent noon, I should, notwithstanding, be able to tell the true time of those eclipses afterwards, when the instrument should be finished. For this purpose, I observed, almost every fair evening, the time by the clock, when the bright star in Orion disappeared behind a fixed obstacle, by applying my eye to a small fighting-hole, made through a piece of brass, fastened to a strong post. The observations were as follows:—

1769.		Star disappeared per clock.	Immersion of 1st satellite, per clock.			Equal altitudes observed.				Hence the Sun on meridian per clock.
		h ' "	February.	h ' "		March.	h ' "	h ' "		h ' "
Day.			Day.			Day.				
Febr.	15	9 26 39	16	14 24 58		19	8 58 52	2 56 52		11 57 37
	22	8 58 52	23	16 17 41			9 2 13	2 53 32		
	24	8 50 57	Hence from the equal altitudes in column 3; the apparent times of the two above immersions are			20	8 56 40	2 58 26		11 57 18
March	3	8 23 21					8 59 59	2 55 7		
	12	7 48 26								
	14	7 40 41								
	17	7 29 4								
	20	7 17 16								
	21	7 13 21								
	28	6 45 44								
			Feb.	h ' "						
			16	14 21 10						
			23	16 15 1						

" From March 20 to May 20, the clock was altered several times, once taken down to be cleaned, removed back to the observatory, and regulated anew. Care, however, was taken to observe equal altitudes

“ altitudes of the Sun on the day preceding and fol-
 “ lowing any visible eclipse of the 1st satellite.
 “ The eclipses and other observations, during this
 “ period, were the following:—

Equal altitudes of the Sun.		Sun on me- ridian per clock.	Observ'd im- mersions of 1st satellite.	Equal altitudes of the Sun.		Sun on me- ridian per clock.	Observed eclipses of 1st satellite.
April 3, 1769.			April 3.	May 4th.			
A. M.	P. M.		Immersion	A. M.	P. M.		
h / "	h / "	h / "	h / "	h / "	h / "	h / "	h / "
8 5 22	4 1 56	12 3 25	14 52 40	8 5 15	3 44 6		
8 8 16	3 59 2			8 8 3	3 41 18	11 54 32	
				8 9 23	3 39 48		
4th.				5th.			May 5th.
8 3 43	4 3 3	12 3 9		8 4 11	3 44 51		Immersion
8 6 38	4 0 10			8 6 59	3 42 4	11 54 22	11 23 45
				8 8 19	3 40 42		
10th.			10th.	6th.			
8 32 8	} cloudy.		Day-light	8 3 8	3 45 37		
8 35 6			16 46 20	8 5 54	3 42 51	11 54 14	
8 36 31				8 7 15			
11th.				11th.			
8 30 22	3 30 43	12 0 20		8 34 51	3 17 12		
8 35 6	3 27 47			8 36 13	3 15 49	11 55 54	
8 36 31	3 26 22			8 37 40	3 14 22		
12th.			12th.	8 39 3	3 12 59		
8 28 55	} cloudy.		11 14 38	15th.			May 14th.
8 31 51				9 12 59	2 39 28		Emersion
8 33 16					2 38 2	11 56 7	9 58 20
14th.				9 15 53	2 36 32		
8 25 42	3 33 56				2 35 7		
Cloud	3 31 1	11 59 38					
8 30 2	2 29 37						

“ May 20, in the morning, the clock was set up
 “ for the last time, pretty near the mean time. It
 “ had no provision for preventing the irregularities
 Vol. LIX. Q q arising

“ arising from heat and cold ; nor could I find lei-
 “ sure to apply any contrivance of this sort. It had
 “ been made some time before, to determine the va-
 “ riations arising from those causes. The pendulum-
 “ rod is a flat steel bar, with a bob weighing about
 “ twelve pounds, and vibrates in a small arch. It
 “ goes eight days, beats dead seconds, does not
 “ stop when wound up, and is kept in motion by a
 “ weight of five pounds.

“ The ill state of my health would not permit
 “ me to sit up at nights, to take equal altitudes
 “ of the stars. I was therefore obliged to content
 “ myself with those of the Sun only. I had,
 “ some time before this, viz. May 12, got a te-
 “ lescope fixed in the meridian, on an axis with
 “ fine steel points ; so that the hair in its focus
 “ could move in no other direction than along
 “ the meridian. I set up two marks, north and
 “ south, about 60 rods distant each, to which it
 “ can readily be adjusted, in a horizontal position,
 “ by a screw ; as it can likewise by another screw in
 “ a vertical position. The two marks were shifted
 “ from day to day, until they were found within less
 “ than one second of time of the true meridian.

“ May 20, I likewise put wires, instead of hairs,
 “ in the telescope of the equal altitude instrument ;
 “ and the following are the observations taken both
 “ with it, and with the meridian or transit telescope,
 “ in the order wherein they were made :

	Equal altitudes of the Sun,	Hence the Sun on meridian.			Observed eclipses of Jupiter's satellites.	Observations with the meridian telescope.			Hence the Sun's center on meridian.
		A. M.	P. M.						
		h ' "	h ' "	h ' "		h ' "	h ' "	h ' "	
May	☉'s up. limb at 1st hair	8 1 30	3 51 28		Emissions.	☉'s western limb at meridian	☉'s eastern limb at ditto	11 55 16	11 56 23½
	D° at 2d hair	8 2 52	3 50 8	11 56 23½					
20	☉'s l. limb at 1st hair	8 4 15	3 48 45						
	D° at 2d hair	8 5 36	3 47 24						
	N. B. As the Sun seems to descend, being inverted in the telescope, his up. limb is set down as com-	8 1 1	3 52 11		1st Satellite.	☉'s western limb	☉'s eastern ditto.	11 55 23	11 56 30
21		Clouds {	3 50 50 3 49 27 3 48 7	11 56 30					
	ing to the upper hair first—though they might as properly be called 1st and 2d as upper and lower hairs	8 0 4 8 1 24 8 2 47 8 4 8	3 53 36 3 52 16 3 50 53	11 56 45		☉'s western limb	Eastern ditto	11 55 39 11 57 53	11 56 46
23									
						☉'s eastern limb	—Passage of ☉'s semi-diameter	11 58 0 0 1 8	11 56 52
24									
						☉'s western limb	Eastern ditto	11 55 53 11 58 9	11 57 1
25		7 59 15 8 0 35 8 1 58 8 3 18	3 54 57 3 53 38 3 52 15 3 50 54	11 57 1					
		7 58 54 7 1 37 8 2 57	3 55 38 3 54 18 3 52 56 3 51 35			☉'s western limb	Eastern ditto	11 56 3 11 58 18	11 57 10½
26									

	Equal altitudes of the Sun.		Hence the Sun on meridian.	Observed eclipses of Jupiter's satellites.	Observations with the meridian telescope.	Hence the Sun's center on meridian.
	A. M. h ' "	P. M. h ' "	h ' "	Emerfions. h ' "	h ' "	h ' "
May 27					☉'s western limb 11 56 12 Eastern ditto 11 58 27	11 57 19½
30					☽'s east limb on meridian. } 20 20 31	
31	☉'s sup. limb at 1st hair } 7 57 29 3 58 49 Ditto at 2d hair } 7 58 49 3 57 30 ☉'s l. limb at 1st hair } 8 0 11 3 56 8 Ditto at 2d hair } 8 1 31 3 54 49		11 58 5½		☉'s west limb on meridian } 11 56 58 + Passage of semi-diameter } 0 1 8	11 58 6
June	Put smaller wires in the telescope. Hence the difference in the intervals				☉'s western limb 11 57 26 Eastern ditto 11 59 41	11 5 33½
2	7 57 9 4 0 6 7 58 29 3 58 47 7 59 53 3 57 22 8 1 13 3 56 3		11 58 34			
3	Transit Day. Equal altitudes were not taken this day, as the instrument was to be otherwise employed in the afternoon.				☉'s western limb 11 57 41 Eastern ditto 11 59 57	11 58 49
4	7 58 10 4 1 18 7 59 34 3 58 35 8 0 54 3 57 15		11 59 1½		☉'s western limb 11 57 54 Eastern ditto 12 0 10	11 59 2
5	7 56 43 4 1 50 7 58 3 4 0 30 7 59 27 3 59 7 8 0 47 3 57 47		11 59 13½			
6	2 50 12 2 48 51 9 11 30 2 47 26		11 59 26	1st Satellite. Em. 10 11 2	☉'s western limb 11 58 18 Eastern ditto 12 0 33	11 59 25½
7	7 57 52 4 1 25 7 59 16 4 0 1 8 0 35		11 59 36	2d Satellite. Em. 8 23 42	☉'s western limb 11 58 27 Eastern ditto 12 0 44 ☽'s w. l. on merid. 3 21 53	11 59 35½

Observed

June	Observed equal Altitudes of the Sun.				Hence the Sun on meridian.	Observed eclipses of Jupiter's satellites.	Observations with the meridian telescope.	Hence the Sun's center on meridian.				
	A. M.		P. M.									
	h	'	"	h	'	"	h	'	"	h	'	"
8	☉'s up. limb } 7 56 27 4 3 12 at 1st hair Ditto at 2d hair } 7 57 48 4 1 52 ☉'s l. limb } 7 59 12 4 0 28 at 1st hair Ditto at 2d hair } 8 0 32 3 59 7				11 59 48		☉'s west limb } 11 58 40 on merid. E. limb ditto } 12 0 57	11 59 48½				
10	7 56 22 4 4 1 7 57 48 4 2 41 7 59 12 4 1 17 8 0 32 3 59 7				12 0 9½							
12							☉'s west limb 11 59 29 East ditto 12 1 45	12 0 37				
13	7 59 13 4 2 30 8 0 33 4 1 11				12 0 50	1st satellite. Em. 12 5 59	☉'s west limb 11 59 42 East ditto 12 1 59	12 0 50½				
14							☉'s west limb 11 59 57 East ditto 12 2 13	12 1 5				
16	7 56 52 4 6 16 7 58 12 4 4 57 7 59 36 4 3 33 8 0 56 4 2 12				12 1 34		☉'s west limb 12 0 26 East ditto 12 2 42 ☿'s center on } 9 6 4 merid.	12 1 34				
17							☉'s west limb 12 0 36 + Passage of se- } 1 08,8 midiameter ☿'s center on } 9 1 50 meridian	12 1 44½ Thermo- meter at } 77				
19							☉'s west limb 12 0 56 + Passage of se- } 1 08,8 mi-diameter ☿'s center on } 8 53 24 meridian	12 2 4½ Therm. 77°				
21							☉'s west limb 12 1 17 East ditto 12 3 34	12 2 25½ Therm. 83° Observed				

June	Observed equal altitudes of the Sun.				Hence the Sun on meridian.	Observed eclipses of Jupiter's satellites.	Observations with the meridian telescope.	Hence the Sun's center on meridian.
	A. M.		P. M.					
22	h	'	"	h	'	"	☉'s west limb 12 1 28 East ditto 12 3 45	12 2 36½ Therm. 74½°
23							☉'s west limb 12 1 39 East ditto 12 3 55	12 2 47 Therm. 73½°
24							☉'s west limb 12 1 49 East ditto 12 4 5	12 2 57 Therm. 84°
25						3d satellite out of the shadow, on applying the eye at 8 ^h 54' 39".	☉'s west limb 12 1 57 East ditto 12 4 14	12 3 5½ Therm. 80°
26							☉'s west limb 12 2 6 East ditto 12 4 23 J's east limb on merid. } 18 13 52	12 3 14½ Therm. 85°
27							☉'s west limb 12 2 14 East ditto 12 4 31 J's east limb on merid. } 19 4 19 U's center on merid. } 8 19 58	12 3 22½ Therm. 88°
28	☉'s up. limb at 1st hair } Ditto at 2d hair } ☉'s l. limb at 1st hair } Ditto at 2d hair }	7 59 11 8 0 31 8 1 55 8 3 15	4 7 45 4 6 25 4 5 0 4 3 15				☉'s west limb 12 2 21 East ditto 12 4 38	12 3 29½
29		8 0 48 8 2 11 8 3 32	4 7 43 4 6 22 4 4 59 4 3 38			1st satellite appeared from behind a cloud, at 10 ^h 25' 1".	☉'s west limb 12 2 29 East ditto 12 4 45	12 3 37 June 30, Therm. 85°

Observed

	Observed equal altitudes of the Sun.		Hence the Sun's on meridian.	Observed eclipses of Jupiter's satellites	Observations with the meridian telescope.	Hence the Sun's center on me- ridian.	
July	A. M. h ' "	P. M. h ' "		3d satellite. h ' "			
2	☉'s up. limb at 1st hair	8 0 24	4 7 28	Im. 11 19 36	☉'s west limb	12 2 52	12 4 0
	Ditto at 2d hair	8 1 44	4 6 8		East ditto	12 5 8	Therm. 81° $\frac{1}{2}$
	☉'s l. limb at 1st hair	8 3 8	4 4 43				
	Ditto at 2d hair	8 4 29	4 3 23				
3		8 0 46	4 7 21		☉'s west limb	12 2 58	12 4 6 $\frac{1}{2}$
		8 2 7	4 6 52		East ditto	12 5 15	Therm. 83°
		8 3 31	4 4 37				
		8 4 51	4 3 16				
4		8 1 9	4 7 13		☉'s west limb	12 3 6	12 4 14 $\frac{1}{2}$
		8 2 30	4 5 32		East ditto	12 5 23	Therm. 87°
		8 3 53	4 4 28				
		8 5 14	4 3 8				
5		8 5 36	4 2 57		☉'s west limb + Passage of se- mi-diameter }	12 3 11 1 8,5	12 4 19 $\frac{1}{2}$ Therm. at 3 o'clock 94° $\frac{1}{2}$
8		8 1 36	4 7 41		☉'s western limb	12 3 36	12 4 44
		8 2 56	4 6 20		Eastern ditto	12 5 52	Therm. 83° $\frac{1}{2}$
		8 4 19	4 4 57				

Table.

Table of Eclipses of Jupiter's Satellites, observed at Norriton; compared with the calculated times of the same Eclipses for Greenwich, in order to fix the longitude of the Norriton observatory. N. B. If the observed times of such of those Eclipses as have been seen at Greenwich should differ from the calculated times, the following difference of longitude, thence deduced, must be corrected accordingly.

1st satellite. Immersions at Norriton. apparent time.				Calculated apparent time of the same for Greenwich.				Long. of Norriton, west of Greenwich, thence deduced.			
1769. Day.	h	'	"	Day.	h	'	"	h	'	"	
Feb. 16	14	21	10	Feb. 16	19	22	29	---	5	1	19
23	16	15	1	23	21	16	35	---	5	1	34
April 3	14	49	25	April 3	19	51	24	---	5	1	59
10	16	46	0	10	21	47	14	---	5	1	14
12	11	14	39	12	16	16	13	---	5	1	34
May 5	11	29	27	May 5	16	31	20	---	5	1	53
Emerfions.				Emerfions.							
21	11	55	13	21	16	56	49	---	5	1	36
June 6	10	11	32	June 6	15	12	59	---	5	1	27
13	12	5	1	13	17	6	31	---	5	1	30

Difference of longitude from a mean of the above 9 eclipses										---	5 1 34

3d satellite, at Norriton; apparent time.				Calculated time for Greenwich.				Hence diff. of long.			
Day.	h	'	"	Day.	h	'	"	h	'	"	
June 25	8	51	33	Emerfion	13	58	34	5	7	1	}
July 2	11	15	36	Immerfion	16	12	29	4	56	53	
Mean diff. of longitude								5	1	57	

N. B. As the emerfion happened fo much fooner, and the immerfion later, than the time given by the Tables, it is concluded, that the ſatellite did not dip fo deep in the ſhadow as the Tables would have it; but the mean of both gives nearly the ſame difference of longitude as the firſt ſatellite.

“ May

“ May 20, Mr. Lukens sent up the astronomical
 “ quadrant, belonging to the East-Jersey proprietors,
 “ of $2\frac{1}{2}$ feet radius ; which I placed in the meridian,
 “ and observed the following zenith distances of stars,
 “ to discover the error of the instrument, if any it had.

Observations with the face westwards.					Ditto with the face eastwards.						
Highest star in the leg of Bootes.	{	May 31	20	36	6	Same star.	{	June 6	20	35	55
		June 4	20	36	0			7	20	35	54
		5	20	36	0			8	20	36	0
<hr/>											
Arcturus.	{	May 31	19	46	18	Arcturus.	{	June 6	19	46	5
		June 1	19	46	14			7	19	46	8
		2	19	46	20			8	19	46	13
		5	19	46	22			10	19	46	11

Zenith dist. with face of quadrant westwards.

Zen. dist. face of quad. east.

The bright star in the Crown. { June 1 12 39 36 { June 6 12 39 34
 { 5 12 39 27 { 10 12 39 18

“ From a mean of the above 18 observations, the
 “ error of the quadrant is $3''\frac{1}{2}$ to be subtracted from
 “ the zenith distance, when the face is westwards, and
 “ added when it is eastward.

Zenith distances of the Sun's limbs observed, and the latitude of the
 observatory deduced separately from each.

Sun's up. limb ; dist. à zenith.					Lat. hence deduced.			Sun's l. limb ; dist. à zenith.					Lat. hence deduced.								
		°	'	''		°	'	''			°	'	''		°	'	''				
May	25	18	48	45		40	10	17	June	8	17	29	33		40	9	48				
	26	18	38	18		40	10	10		9	17	24	35		40	9	47				
	27	18	28	21		40	10	10		10	17	20	5		40	9	49				
June	1	17	43	47	cloudy and doubtful				11	17	15	59		40	9	52					
	2	17	36	16			40	10	2	14	17	6	9		40	9	58				
Doubtful	4	17	21	51		40	9	52													
	6	17	8	53		40	9	34													
	7	17	3	21		40	9	47													
	12	16	41	10		40	10	14													
	13	16	37	45		40	10	8													
Mean of the above observations					}	Mean of the above 5 obser-					}	vations of ☉'s lower limb					}	40			9 51
of ☉'s upper limb						of ☉'s lower limb															
Mean of the 5 obser. of ☉'s l. limb																					

The mean of both, viz. 40 9 56 is taken for the latitude of the observatory.

“ The difference of the above observations is
 “ greater than might be wished. All that I can of-
 “ fer to excuse them is the want of better instru-
 “ ments; although I think the differences were
 “ much owing to the action of the Sun on the
 “ wooden frame, which supported the quadrant.
 “ For I always found, that when the shutter in the
 “ roof was opened, the plummet-wire would, in a
 “ minute or two, leave the point, although it had
 “ stood quietly over it all the forenoon. Never-
 “ theless, a *mean* from so many observations may be
 “ supposed very near the truth; since, if we leave
 “ out that of June 6, which differs most from the
 “ others, the *mean* of them will be but 2'' greater
 “ than the latitude set down above.”——

So far I have given Mr. Rittenhouse's account of his observations, previous and subsequent to the transit; for regulating his time-piece, and fixing the latitude and longitude; containing many months work, *viz.* from February 15 to July 8. More observations have been taken since, but the above are thought sufficient.

It hath been already mentioned, that it was not till Thursday afternoon, June 1, that Mr. Lukens and myself arrived at Norriton, with a design to continue with Mr. Rittenhouse till the transit should be over. When we set out, the prospect before us was very discouraging. That day, and several preceding, had been constantly overcast with clouds, and frequent heavy rains, a thing not common for so long a period at that season of the year, in this part of America. But, on Thursday evening, by one of those sudden transitions which we often experience here, the
 weather

weather became perfectly clear in less than the space of one hour, and continued the day following, as well as the day of the transit, in such a state of serenity, splendor of sunshine, and purity of atmosphere, that not the least appearance of cloud was to be seen in the whole heavens.

June 2, and the forenoon of June 3, were spent in making the necessary preparations; such as, examining and marking the *foci* of the telescopes, particularly the reflector with and without the micrometer, and in its different powers. The reflector was also placed on a polar axis; and such supports were contrived for resting the ends of the refractors, as might give them a motion as nearly parallel to the plane of the equator as such hasty preparations would permit. Several diameters of the Sun were taken during this time, and the micrometer examined by such other methods as the time would allow.

The Sun was so intensely bright on the day of the transit, that it was found best, early in the forenoon, to lay aside the coloured glasses, brought with the reflecting telescope from England; and to put on deeply-smoked glasses, which Mr. Lukens prepared, in their room; and which gave a much more beautiful and well-defined appearance of the Sun.

Mr. Rittenhouse, on a supposition of the Sun's horizontal parallax being but $8''$, had, in one of his calculations of the time of the transit, made in September, 1768, brought out the first external contact, at Philadelphia, to be June 3, $2^h 11'$, mean time. It happened, that he was not many seconds wrong in this, although most other calculations made it from $6'$ to $8'$ later for Philadelphia.

We thought it prudent therefore, at one o'clock, to take off the micrometer from the reflector, which had been used with a magnifying power of 95 times; and, after adjusting the *focus*, continued the same power for the reasons mentioned * below, in order to observe the transit; and lest the external contact might happen still sooner than the earliest predicted time, it was resolved, during the hour from one till two, to keep an alternate watch, through the reflector, on that half of the Sun's limb where the contact must happen; while those not thus employed were making all other preparations as follows, *viz.*

1. That each of us might the better exercise our own judgment, without being influenced, or thrown into any agitation or surprize by the others; it was agreed to transact every thing by signals, and that one observer should not know what the others were doing. The situation of the telescopes, the reflector being within the observatory, and the two refractors, mounted at some distance from each other without it, favoured this purpose. Wherefore,

2. Two persons, *viz.* Mr. Sellers, one of our committee, for whom no telescope could be pro-

* As the refracting telescopes gave but a small field, and were very unmanageable, on account of their length, and the Sun's great altitude, it was thought best to use a smaller power and larger field with the reflector, that if the contact should happen at a different part of limb than where it was expected, one of us, at least, might be sure not to miss it, but give notice to the others. It was agreed, however, that if the contact happened at or very near the part of the limb where we did expect it, no such notice was to be given. It was, although, thought best to have some difference in the magnifying powers; and the vision with the reflector was so distinct and well defined, that I am well pleased I used no higher power.

vided,

vided, and Mr. Archibald McClean, both men of abilities, and accustomed to astronomical observations, were placed in one window of the observatory, to count the clock, and take the signals from Mr. Lukens. Two others, who live in Mr. Rittenhouse's family, and have been trained by him to services of this kind, stood in another window, within the observatory, to count the time, and take his signals. I was within hearing of the beats of the clock, and was to count and set down my own time.

These preliminaries thus settled, at two o'clock, each of us applied to our respective telescopes; but as there was a great concourse of many of the principal inhabitants of the county, we were apprehensive, that our scheme for silence and order might be interrupted by the impatience and curiosity natural on such occasions. We therefore informed the gentlemen, who had honoured us with their company, that the accuracy and success of our observations would depend on our not being disturbed with the least noise, till the contacts were over. And to do the company justice, during the 12 minutes that ensued before the first contact, there could not have been a more solemn pause of expectation and silence, if each individual had stood ready to receive the sentence that was to give him life or death. So regular and quiet was the whole, that, far from hearing a word spoken, I did not even hear the feet of the four counters, who had passed behind me from the windows to the clock; and I was surprized, when I rose up and turned to the clock, to find them all there before me, counting up their seconds to an even number; as I imagined,
from

from the deep silence, that my associates had yet seen nothing of Venus.—

As the contacts are reckoned to be one of the most essential articles relative to this phenomenon, it is material, before we set down their times, to give a particular account of the manner in which each observer judged of them, and the other circumstances attending them.

MR. RITTENHOUSE'S ACCOUNT OF THE CONTACTS.

“ At 2^h 11' 39" per clock, the Reverend Mr.
 “ Barton, of Lancaster, who assisted me at the te-
 “ lescope, on receiving my signal, as had been
 “ agreed, instantaneously communicated it, by wav-
 “ ing a handkerchief, to the counters at the window,
 “ who, walking softly to the clock, counting as they
 “ went along, noted down their times separately,
 “ agreeing to the same second. And three seconds
 “ sooner than this, to the best of my judgment, was
 “ the time when the least impression made by Venus
 “ on the Sun's limb could be seen through my te-
 “ lescope.

“ When the Planet had advanced about one third
 “ of her diameter on the Sun, as I was steadily
 “ viewing its progress, my sight was suddenly at-
 “ tracted by a beam of light, which broke through
 “ on that side of Venus yet off the Sun. Its figure
 “ was that of a broad-based pyramid; situated at
 “ about 40 or 45 degrees on the limb of Venus,
 “ from a line passing through her center and the
 “ Sun's

Fig. 2.

Fig. 1.

Fig. 3.

True Transit Line

II

I. 46".4

I. 46".6

I. 57".6

2. 13".5

2. 52".7

2. 8".6

7.44".57

Line parallel to the Equator

10.14".74

Line parallel to the Equator

18.0".08

25

24

23

22

21

20

19

18

17

16

Fig. 4.

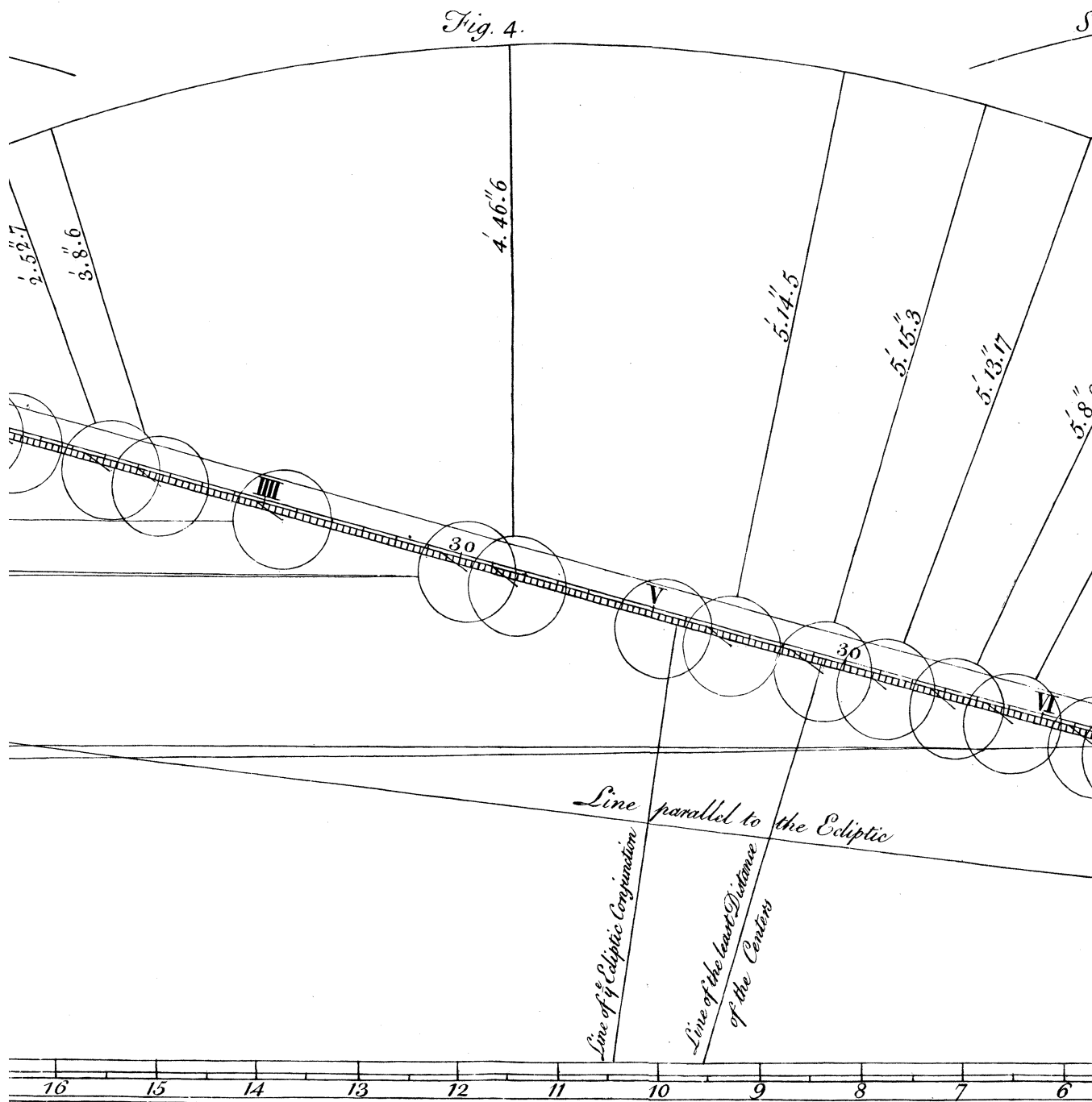
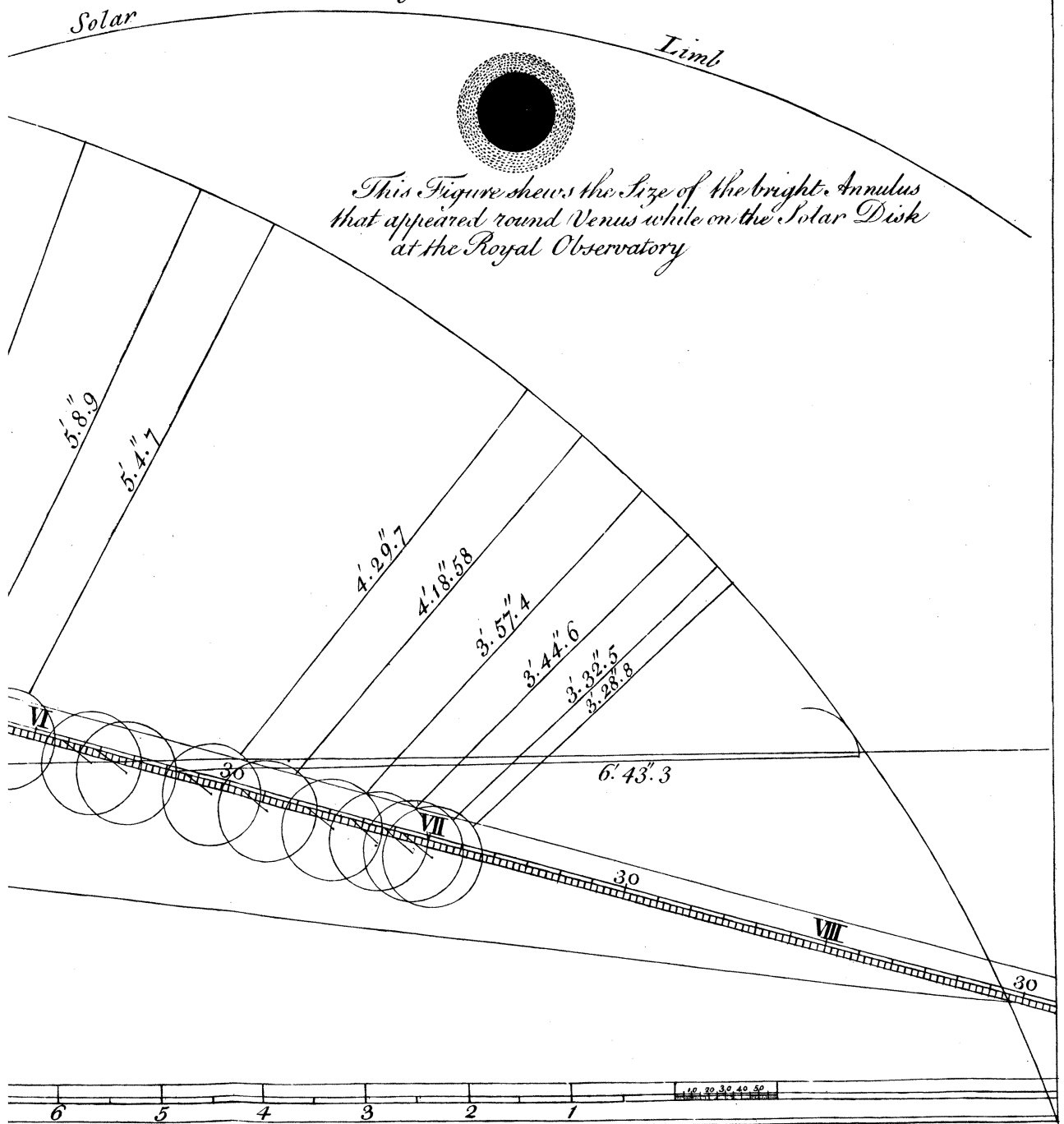


Fig. 5.



“ Sun’s, and to the left hand of that line, as seen
 “ through my telescope, which inverted. See TAB.
 “ XV. fig. 1.—About the same time, the Sun’s light
 “ began to spread round Venus on each side, from the
 “ points where their limbs intersected each other, as is
 “ likewise represented in fig. 1.

“ As Venus advanced, the point of the pyramid
 “ still grew lower, and its circular base wider, until
 “ it met the light which crept round from the points
 “ of intersection of the two limbs: so that when
 “ half the Planet appeared on the Sun, the other
 “ half was entirely surrounded by a semicircular
 “ light, best defined on the side next to the body of
 “ Venus, which continually grew brighter, till the
 “ time of the internal contact. See fig. 2.

“ Imagination cannot form any thing more beau-
 “ tifully serene and quiet than was the air during the
 “ whole time; nor did I ever see the Sun’s limb
 “ more perfectly defined, or more free from any
 “ tremulous motion; to which his great altitude
 “ undoubtedly contributed much. When the in-
 “ ternal contact (as it is called) drew nigh, I fore-
 “ saw that it would be very difficult to fix the time
 “ with any certainty, on account of the great breadth
 “ and brightness of the light which surrounded that
 “ part of Venus yet off the Sun. After some con-
 “ sideration, I resolved to judge as well as I could of
 “ the co-incidence of the limbs; and accordingly
 “ gave the signal for the internal contact at $2^h 28' 45''$
 “ by the clock, and immediately began to count
 “ seconds, which any one, accustomed to it, may
 “ do, for a minute or two, very near the truth. In
 “ this manner, I counted no less than $1' 32''$ before
 “ the

“ the effects of the atmosphere of Venus on the
 “ Sun’s limb wholly disappeared, leaving that part
 “ of the limb as well defined as the rest. From
 “ this I concluded, that I had given the signal too
 “ soon ; and the times given by the other observers
 “ confirm me in this opinion.”

Mr. LUKENS’S Account of the CONTACTS.

“ The telescope I used, being a refracting one of
 “ 42 feet, giving but a small field, and something
 “ difficult to manage ; I was obliged to move often,
 “ and apprehend that I did not discover the first
 “ external contact exactly. For, after one of those
 “ movements, on bringing the glass to bear again on
 “ that part of the Sun’s limb where Venus was ex-
 “ pected, I saw a large tremulous shadow, already
 “ somewhat advanced, and seeming to press still in-
 “ wards on the Sun’s limb. Having contemplated
 “ this for a few seconds, and perceiving the appear-
 “ ance grow more dark, and make a better-defined
 “ impression on the limb, I gave the signal to the
 “ persons who counted time for me, which they
 “ noted down separately at 2^h 12’ 3’’ by the clock.
 “ When Venus was near one half her diameter
 “ advanced on the Sun, I saw a border of light en-
 “ compassing that part of her which was yet off the
 “ Sun. This was so bright, that it rendered that
 “ part of Venus visible, and pretty well defined, al-
 “ though off the Sun. But, towards the internal
 “ contact,

“ contact, the circular border of light became of a
 “ more dusky colour, especially at the two points
 “ where the luminous segments of the Sun’s limb
 “ were ready to close round the Planet. This
 “ duskiness did not seem to part wholly from the
 “ Sun’s limb, at the time I apprehended the body of
 “ Venus to be wholly entered on the Sun, and when
 “ I gave the signal for the internal contact; which
 “ was noted at $2^h 28' 58''$ by the clock. And I
 “ judge from $6''$ to $8''$ more, before I saw the Sun’s
 “ limb clear of this dusky surrounding shadow, and
 “ as well defined as before the first contact.”

Dr. SMITH’s Account of the CONTACTS.

“ Having, for reasons already assigned, determined
 “ to continue one of the smaller powers of the Grego-
 “ rian reflector, for observing the contacts (viz. that
 “ which we had been using, and were again to use, with
 “ the micrometer, magnifying 95 times), I had a large
 “ field, taking in, at least, one half of the Sun’s disk; and
 “ the telescope was so firmly supported (with its axis
 “ in a polar direction), that it could not be shaken
 “ by any motion on the earthen floor of the observa-
 “ tory, and required only a small movement of one
 “ of the handles of the rack-work to manage it.
 “ With these advantages, it was easy to keep any
 “ part of the Sun’s limb in the middle of the field,
 “ without neglecting to cast my eye, every three or
 “ four seconds, on every other part of the limb
 VOL. LIX. S s “ on

“ on both sides, where there was any possibility of
“ the contact to happen,

“ It being now within about half a minute of the time
“ which Mr. Rittenhouse had calculated for the first
“ contact, I called to the four counters at the win-
“ dows, to be very attentive to those who were to give
“ the signals from the telescopes without doors ; and
“ turning my eye to that part of the limb where the
“ contact was expected, I had been, for several se-
“ conds, viewing it stedfastly, when, all at once, I saw
“ something strike into it like a watry pointed sha-
“ dow, appearing to give a tremulous motion to that
“ part of the Sun’s limb, although the telescope
“ stood quite firm, and not the least disturbance or
“ undulation was perceptible in any other part of
“ the limb.

“ The idea I had formed of the contact was—
“ that Venus would instantaneously make a well-
“ defined black and small dent or impresson on the
“ Sun. But this appearance was so different, the
“ disturbance on the Sun’s limb so undulatory,
“ pointed, ill-defined, waterish, and occupying a
“ larger portion of the limb than I expected, that I
“ was held in a suspense of five or six seconds, to
“ examine whether it might not be some small skirt
“ of a watery flying cloud. But perceiving this
“ shadow, or whatever else it was, to press still for-
“ ward on the limb, with the same tremulous,
“ pointed appearance (the longest points towards its
“ middle), I began to count the clock for either
“ fifteen or sixteen seconds, when a well defined
“ black dent, occupying a less space on the Sun’s
“ limb, became plainly visible. I then quitted the
“ telescope,

“ telescope, and turned to the clock, to note this
 “ time for the contact, which was $2^h 12' 5''$. About
 “ $22''$ sooner than this (being doubtful to two or
 “ three seconds at first) was the first impression I
 “ saw on the limb; which I have marked accord-
 “ ingly at $2^h 11' 40''$ to $43''$. If this first impres-
 “ sion is to be taken for the external contact, I think
 “ it might be judged of to a single second of time;
 “ which one could not do by several seconds, either
 “ with respect to the internal contact, or even with
 “ respect to the moment of the distinct black dent
 “ made at the external contact, both which are far
 “ from being instantaneously perceptible. Whether
 “ a telescope of larger powers than what I used
 “ might not have shewn this first impression sooner
 “ (be it an atmosphere or whatever else), I will not
 “ determine; though from Mr. Rittenhouse’s time
 “ I think it probably would. But I am sure that I
 “ saw the first stroke that was perceptible through
 “ my telescope, and might have noted it to a single
 “ second, had I expected it in that way.

“ As to the internal contact, the thread of light,
 “ coming round from both sides of the Sun’s limb,
 “ did not close instantaneously, but with an uncer-
 “ tainty of several seconds, the points of the threads
 “ darting into each other, and parting again, in a
 “ quivering manner, several times before they finally
 “ adhered. I waited for this adherence with all the
 “ attention in my power, and noted it down for the
 “ internal contact at $2^h 29' 5''$, a few seconds later
 “ than Mr. Lukens, who took the same method of
 “ judging.

“ Having quitted my telescope to note down the
 “ time, the gentlemen who counted for us, as well
 “ as several others now come into the observatory,
 “ were anxious to see Venus on the Sun through the
 “ reflector, as it was easily manageable; an indul-
 “ gence not to be denied; and therefore I did not sit
 “ down to it again till about four or five minutes
 “ before the internal contact, and then not with
 “ much attention till the contact was at hand; so
 “ that I saw none of those appearances, on the part
 “ of Venus off the Sun, mentioned by my associates.
 “ But their account may be depended on; for Mr.
 “ Rittenhouse’s abilities have been spoken of before;
 “ and few persons have a better judgment, a correcter
 “ eye, or have been more accustomed to view ob-
 “ jects, both celestial and terrestrial, through te-
 “ lescopes, than Mr. Lukens.

“ As to the small differences in the times of our
 “ contacts, it is presumed, they may be easily re-
 “ conciled, partly from the different powers of the
 “ telescopes, and partly from the other circumstances
 “ mentioned in the manner of judging of them.
 “ At any rate, we have set them down faithfully.

“ As to the first disturbance made on the Sun’s
 “ limb, it may be worth considering, whether it was
 “ really from the interposition of the limb of Venus,
 “ or of her atmosphere? The former, one could not
 “ easily imagine it to be, unless her limb and body
 “ were much more uneven than they appeared to
 “ be when seen on the Sun. An atmosphere it
 “ might more probably seem to be, not only from
 “ the faintness of the colour, but the undulatory
 “ morion,

“ motion, which might arise from the growing den-
 “ sity of the atmosphere, as it pushes forward on the
 “ Sun, varying the refraction of the rays. If such an
 “ atmosphere be allowed, then it probably gives the
 “ same tremulous motion, at the internal contact, to
 “ the thread of light creeping round Venus; and
 “ prevents its closing quietly till the atmosphere (or
 “ at least its densest part) be wholly on the Sun; and
 “ consequently the true coincidence of the limbs be
 “ past. For though the atmosphere of Venus can-
 “ not be seen on the Sun, yet that part which is sur-
 “ rounding, or just entering on the Sun’s limb, hav-
 “ ing, as it were, a darker ground behind it, may be
 “ visible. But these are only little conjectures sub-
 “ mitted to others; though if they have any founda-
 “ tion, it would make some difference in the time
 “ estimated between the contacts.”

General Table of the contacts of the limbs of the Sun and Venus, as observed at Norriton, June 3, 1769, reduced to apparent time.

N. B. June 3, by the preceding Tables of the work, the Sun's center was on the meridian, at $11^h 58' 49''$ by the clock, and June 4, at $11^h 59' 2''$, and therefore gained $13''$ in 24 hours of apparent time. Wherefore at noon June 3, the clock being $1' 11''$ slow of apparent time, it was only $1' 10''$ slow at the observation of the contacts. Whence

The apparent time of the different contacts was :

External contact, by Dr. Smith.	Extern: contact, by Mr. Lukens.	External contact, by Mr. Rittenhouse.
$\left. \begin{array}{l} \text{1st visible impression on} \\ \text{the Sun's limb, in form} \\ \text{of a quivering dusky} \\ \text{shadow, with many} \\ \text{points} \\ \text{A well defined black} \\ \text{dent in the Sun's limb,} \\ \text{at} \end{array} \right\} \begin{array}{l} h' '' '' \\ 2 \ 12 \ 50 \text{ to } 53 \\ \text{Uncertain to } 3'' \\ \text{or } 4''. \\ 2 \ 13 \ 15 \end{array}$	$\left. \begin{array}{l} \text{A small dent} \\ \text{in the Sun's} \\ \text{limb} \end{array} \right\} \begin{array}{l} h' '' '' \\ 2 \ 13 \ 13 \end{array}$	$\left. \begin{array}{l} \text{Judged of as} \\ \text{described in his} \\ \text{account} \end{array} \right\} \begin{array}{l} h' '' \\ 2 \ 12 \ 49 \end{array}$
Internal contact.	Internal contact.	Internal contact.
$\left. \begin{array}{l} \text{Judged from a thread} \\ \text{or crescent of light,} \\ \text{closing round the dark} \\ \text{body of Venus, with a} \\ \text{tremulous motion, at} \end{array} \right\} \begin{array}{l} 2 \ 30 \ 15 \end{array}$	$2 \ 30 \ 8 \text{ to } 14$	$\left. \begin{array}{l} \text{Judged of as} \\ \text{described in fig.} \\ \text{3d of his ac-} \\ \text{count, Plate xv.} \end{array} \right\} \begin{array}{l} 2 \ 29 \ 55 \end{array}$

“ When Venus was fully entered on the Sun's
 “ limb, and we had satisfied ourselves by comparing
 “ our different notes of the contacts, which were
 “ thrown together on the table of the observatory, we
 “ prepared for the micrometer, and other observa-
 “ tions. The greatest part of the micrometer obser-
 “ vations were taken by me, while Mr. Rittenhouse
 “ undertook to take another set of observations;
 “ namely,

“ namely, the appulses of the limbs of the Sun, and
 “ the center of Venus, to the cross hairs of the equal
 “ altitude telescope ; Mr. Lukens taking and writing
 “ down the time for him.

The whole observations, reduced to apparent time, are as follows :

No. of observations.	App. time. June 3, 1769.			Micrometer measures of the least distance of the nearest limbs of the Sun and Venus.		Angular value of the micrometer measures.	Parallax of Venus from the Sun, adjusted to the times of the micrometer observations, for projecting the transit ; by Mr. Rittenhouse.		
	h	'	"	Inches	seconds		In the vertical	In the path of Venus.	Perpendicular to the path.
						' "	"	"	"
R. 1	3	7	19	o	4 0,5	1 45,4	14,54	13,67	4,94
R. 2	3	11	39	o	4 12	1 57,6	14,74	13,88	4,96
L. 3	3	17	42	o	5 2	2 13,5	15,09	14,24	5,01
R. 4	3	32	3	o	6 14	2 52,7	15,77	14,92	5,13
R. 5	3	40	4	o	7 4	3 8,6	16,17	15,32	5,23
6	4	35	5	o	10 21,5	4 46,67	18,45	17,45	6,5
7	4	57	9	o	11 19,5	5 11,05	19,02	17,95	6,32
8	5	7	49	o	11 22,75	5 14,5	19,5	18,36	6,63
9	5	21	40	o	11 23,5	5 15,3	19,88	18,64	6,98
10	5	31	46	o	11 21,5	5 13,7	20,12	18,8	7,23
11	5	42	38	o	11 17,5	5 8,93	20,36	18,95	7,48
12	5	51	10	o	11 13,5	5 4,7	20,52	19,06	7,67
13	6	22	4	o	10 5,5	4 29,7	21,0	19,21	8,57
14	6	31	5	o	9 20	4 18,58	21,12	19,22	8,82
15	6	41	24	o	9 0	3 57,38	21,22	19,15	9,14
L. 16	6	48	12	o	8 13	3 44,66	21,26	19,12	9,31
17	6	53	30	o	8 1,5	3 32,47	21,28	19,04	9,49
R. 18	6	56	22	o	7 23	3 28,76	21,29	19,02	9,56

Distance of the limbs of the Sun and Venus, taken in chords, parallel to the plane of the equator.						Parallax of Venus from the Sun, adjusted as above.		
R.	1	3 58 53	☉'s e. limb	o 17 14,3	7 44,57	17,0	16,1	5,40
	2	4 27 18	Ditto	1 3 6	10 14,74	18,16	17,18	5,86
	3	6 4 27	Ditto	2 0 20	18 0,08	20,75	19,16	8,06
	4	6 9 28	☉'s w. limb	o 15 6,5	6 43,27	20,81	19,2	8,2

Observations.	N ^o of ob-	Diameters of Venus on the Sun, June 3, 1769.			Diameters of the Sun, June 2, P. M.		
		P. M.	Inches	seconds	h	'	"
R.	1	3 0	0 2	4,5	R.	3 50	40
	2	3 2	0 2	4,5		3 52	0
L.	3	3 4	0 2	5		4 37	0
	4	4 15	0 2	4,7			
	5	5 55	0 2	4,7			
R.	6	5 58	0 2	5—			

A. M. June 3.			horizontal diameters.
R.	8 35	0	3 11 13,5
L.	8 40	0	3 11 16—
	8 45	0	3 11 13,5
P. M.			
	12 35	0	3 11 13
R.	12 40	0	3 11 12,5
	4 40	0	3 11 10,5

The above times are set down by the clock, according to the vulgar reckoning; as are all the micrometer observations of the Sun's diameters.

From a mean of the above fix diameters of Venus on the Sun, allowing for the error of adjustment, as mentioned below :

	'	"
Venus's diameter, for the day of the transit, was	0	57,3
The Sun's semidiameter, from a mean of the five horizontal diameters, taken the same day	15	47,0
Or, from a mean of four, taken that day, leaving out the second, which Mr. Lukens thinks he may have taken too large	15	45,0

All the micrometer observations were separately reduced to their value in minutes and seconds, both by Mr. Rittenhouse and myself. Many more might have been taken ; but as so many persons were desirous of looking through the telescope, they could not well be denied ; and the number above set down are found fully sufficient for all the purposes of the projection ; especially as they have been found to agree so well with each other.

Such of the micrometer measures as were taken by Mr. Rittenhouse or Mr. Lukens, are marked with the initials of their names. All the others I am answerable for.

Our observations being thus finished, Mr. Rittenhouse was pleased to undertake the projection of the transit

transit from them; and his account of the work follows :

Delineation of the transit of Venus over the Sun, according to the Norriton observations, with the principles of the work. By Mr. Rittenhouse. See Tab. XV. fig. 4.

“ The Sun’s horizontal parallax is assumed $8''{,}65$
 “ at his mean distance from the earth; from which,
 “ and the observed least distance of the centers of the
 “ Sun and Venus, the chord for the transit line was
 “ laid down. The semi-diameters of the Sun and
 “ Venus are taken as by the above observations.
 “ One point in the transit-line was then fixed by the
 “ first micrometer distance of the limbs at $3^h 7' 19''$
 “ apparent time. This line was carefully divided in-
 “ to hours and minutes, on the supposition that Ve-
 “ nus moves $240''{,}36$ over the Sun’s disk in an hour,
 “ according to a calculation I had formerly made
 “ from Halley’s Tables. The place of Venus’s cen-
 “ ter in the transit-line was then marked to the times
 “ of each of the micrometer observations, and from
 “ thence the *apparent place* of her center found, by
 “ setting off the quantity of her parallax from the
 “ Sun in its proper direction. About each of the
 “ centers so found, a circle is described with the rad.
 “ $28''{,}6$, her observed semi-diameter. Blank lines
 “ were next drawn through the Sun’s center, and the
 “ apparent place of the center of Venus. On these
 “ the red lines were drawn from the Sun’s limb, pre-
 “ cisely of such length as we found them by the mi-
 “ crometer; so that it may be seen at once how
 “ far the micrometer measures agree with each
 Vol. LIX. T t “ other,

“ other, by observing how much they exceed or fall
 “ short of reaching the limb of Venus. Out of the
 “ 18 that were taken, 14 of them correspond so well
 “ that I am convinced they may be depended upon.
 “ The 4th which I have set down, and only one
 “ other, which will be found omitted, differ some-
 “ thing from what they ought to be; which might
 “ easily happen, either from any mistake in noting
 “ the time, or in reading the *vernier* of the micro-
 “ meter, or not fixing it exactly in the direction of
 “ the nearest distance of the limbs; tho’ great care was
 “ taken in this part, by sweeping it constantly round
 “ to try the truth of the contacts that were formed.

“ The measures intended to be taken in chords
 “ parallel to the equator, are very near the truth, con-
 “ sidering that, in setting the micrometer to that di-
 “ rection, we had only the truth of the polar axis to
 “ depend on, which was constructed hastily to an-
 “ swer the purpose of the day, and was not exactly
 “ true, as a small mot on of the rack work that raises
 “ or depresses the telescope was sometimes necessary
 “ to keep the Sun in the field. Three of these mea-
 “ sures, parallel to the equator, agree with each
 “ other, and with all the rest of the micrometer ob-
 “ servations, on supposing the chord in which they
 “ were taken inclined half a degree to the plane of
 “ the equator. The fourth of these measures is still
 “ more nearly parallel to the equator, but diverges a
 “ little the other way. These chords are delineated
 “ in the * projection, and serve to confirm the other
 “ work.

* It was intended also to have confirmed the projection still
 further, by the observations made of the appulses of the limbs of

“ All

“ All the parallaxes of Venus from the Sun were
 “ taken from a large projection on a scale of half an
 “ inch to one second, and then reduced to the scale
 “ of this delineation. After calculating some of
 “ those parallaxes, and finding those given by the
 “ projection constantly true to the first decimal place,
 “ any further nicety was thought needless.

0 ' "

The angle of Venus's visible way } 8 28 27
 with the ecliptic, I find

The angle of the ecliptic with a }
 parallel of declination at 3^h } 7 5 13 decreasing 53" per hour.
 P. M.

The latitude of the observatory, as } 40 9 56
 above laid down

Hence the parallaxes were fitted to each of the
 micrometer observations, as above.

If a computation be made with the 1st micrometer obser- } " ' "
 vation of the distance of the limbs, we shall find the } 5 26 16—
 time of the least distance of the centers of the Sun and
 Venus, as seen from the earth's center; to have been

the Sun and center of Venus to the cross-hairs of the equal alti-
 tude instrument; but it was found that so many lines would
 confuse the figure. And the micrometer observations answering
 so well, more were thought needless. Besides this, no fractions
 of seconds could be got in the other observations; though, ne-
 vertheless, a good separate projection may be made by them.

If a like computation be made from the 16th observation, } $\begin{matrix} h & ' & '' \\ 5 & 26 & 21 \end{matrix}$
it will be found

By comparing some other observations with these, I conclude, the time of the least distance of the centers was } $\begin{matrix} 5 & 26 & 20 \end{matrix}$

$\begin{matrix} o & ' & '' \\ 8 & 28 & 27 \end{matrix}$
Then as radius to tangent of the angle }
of the ecliptic, with path of Venus } $\begin{matrix} 9,1731571 \\ 2,7853298 \end{matrix}$
So is the least distance of the centers } $\begin{matrix} 610 \end{matrix}$

To the distance of Venus's place, when }
nearest the Sun's center, from her } $\begin{matrix} 90,88 & 1,9584869 \end{matrix}$
place at the time of ecliptic con- }
junction }

$\begin{matrix} h & ' & '' \\ 0 & 22 & 41 \end{matrix}$
Which reduced to time (to be subtracted) viz. }
From time of the least distance of the centers } $\begin{matrix} 5 & 26 & 20 \end{matrix}$
Leaves for the time of ecliptic conjunction } $\begin{matrix} 5 & 3 & 39 \end{matrix}$

$\begin{matrix} o & ' & '' \\ 8 & 28 & 27 \end{matrix}$
As radius to secant of } $\begin{matrix} 10,0047676 \\ 2,7853298 \end{matrix}$
So is } $\begin{matrix} 610 \end{matrix}$

To the geocentric latitude of Venus at }
the time of ecliptic conjunction } $\begin{matrix} 616,73 & 2,7900974 \end{matrix}$

From the logarithm of which subtract the difference of the }
logarithms of the distance of Venus from the Earth and } $\begin{matrix} 0,4002370 \end{matrix}$
from the Sun }

$\begin{matrix} ' & '' \\ = & 4 & 5,39 \end{matrix}$
Remains the logarithm of the } $\begin{matrix} 2,3898604 \end{matrix}$
heliocentric latitude }

$\begin{matrix} o & ' & '' \\ 3 & 23 & 20 \end{matrix}$
As tangent of inclination of Venus's orbit } $\begin{matrix} 8,7724442 \\ 7,0754375 \end{matrix}$
To radius; so is tangent of Venus's helio- } $\begin{matrix} 0 & 4 & 5,39 \end{matrix}$
centric latitude }

To the sine of her distance from node in } $\begin{matrix} 1 & 9 & 4 \end{matrix}$ $\begin{matrix} 8,3029933 \end{matrix}$
the ecliptic }

The

	S	°	'	"
The Sun's place at the time of the ecliptic conjunction (by Halley's Tab.) was	2	13	26	32
Add the distance of the node from the Sun	0	1	9	4
The sum is the place of the ascending node of Venus	2	14	35	36
The place of Venus, by Halley's Tables, to the same time	8	13	26	22

That is, ten seconds too little.

In order to find the error of the micrometer (if any), Jupiter's diameter was measured to the right and to the left; and Mr. Rittenhouse afterwards took the trouble to measure the diameter of a white painted circle both ways ten times. This work was performed early in the morning before sun-rise, when the air was still, and free from all tremulous motion; the result of which, on a mean of those to the right, and a like mean of those to the left, was an error of adjustment for the micrometer of 1'',12 to be subtracted; which was accordingly allowed for in the reduction of all the micrometer measures.

Thus we have given a full and faithful account of our work. We could have wished to have comprized it in less room. Had our latitude and longitude been well fixed, as they had been at Philadelphia, by able mathematicians, beforehand, a considerable part of our work might have been saved. But as it was necessary to shew, that such pains have been taken in these material articles, that they may be depended on; and as we had opportunities

portunities of observation, from the goodness of the weather, and other circumstances, which cannot have happened to the generality of observers in many parts of the world, we thought we should be the easier excused by men of science, for the insertion of twenty superfluous things, than the neglect of any thing material in the account of a phenomenon, which will never be observed again by any of the present generation of men.

I am,

GENTLEMEN,

with great respect,

Your most obedient,

humble servant,

Philadelphia, July 19,
1769.

William Smith.

N. B. Fig. 5, plate XV, represents the appearance of Venus on the Sun to the Reverend Mr. Hitchins, at the Royal Observatory. See *Philos. Transf.* vol. LVIII. for 1768, p. 363.